Hydrogen-Helium Mixtures: Fundamental Measurements, Neutral Droplet Buoyancy, Evaporation, and Boiling

Completed Technology Project (2014 - 2018)

Project Introduction

Research groups at the Marshall Space Flight Center (MSFC) and the Kennedy Space Center (KSC) have contacted our laboratory in need of experimental measurements for gaseous helium and liquid hydrogen mixtures. These measurements and fundamental property models form the foundation for long-duration propellant modeling, a top technical challenge under TA01 Launch Propulsion Systems. The objective of this proposal is to establish a working relationship with these groups and provide experimental measurements and basic property models that are necessary to accurately model the interactions between helium and hydrogen that occur in the liquid fuel tanks under launch and in space conditions. Liquid hydrogen fuel tanks are pressurized with helium as the tank is emptied due to the fast response and high reliability of the method. This creates a hydrogen-helium mixture within the fuel tank. The interaction between liquid hydrogen and gaseous helium in a microgravity system is complex and difficult to model. Compounding this difficulty is the lack of fundamental property measurements and models of cryogenic helium-hydrogen mixtures that form the basis for predictive model development. Collaboration with researchers at the Kennedy Space Center is already underway. An initial experiment is needed to measure precision PVT-x data of the helium-hydrogen fluid phase envelope. This fundamental property study will be supplemented with measurements of the evaporation, via mass diffusion, of hydrogen droplets in helium. Helium-hydrogen phase change experiments on typical tank materials are also necessary for model development. Lack of these measurements and models will remain a key barrier to propellant modeling for NASA. I have recently retrofitted a Rubotherm ISOSORP 2000 densimeter for cryogenic service with a vibration isolated cryogenic refrigerator. The Rubotherm ISOSORP 2000 uses a well established technology to conduct density and sorption measurements of fluids with a high level of accuracy. The Rubotherm system has been outfitted with a vacuum chamber and cryocooler to achieve temperatures lower than 10 K. Density and sorption measurements of hydrogen-helium mixtures can be readily conducted with the existing system. The evaporation of liquid hydrogen in gaseous helium can be investigated by constructing a simple Pyrex cylinder with copper cooling plates on both ends and observing the droplet evaporation. The existing system and equipment that is available can be used, or easily modified, to conduct numerous experiments on hydrogen-helium mixtures. The versatility of this experimental system, and support from this fellowship, will enable a rich collaboration with NASA.

Anticipated Benefits

The objective of this proposal is to provide experimental measurements and basic property models that are necessary to accurately model the interactions between helium and hydrogen that occur in the liquid fuel tanks under launch and in space conditions. These measurements and models will enable propellant modeling for NASA.

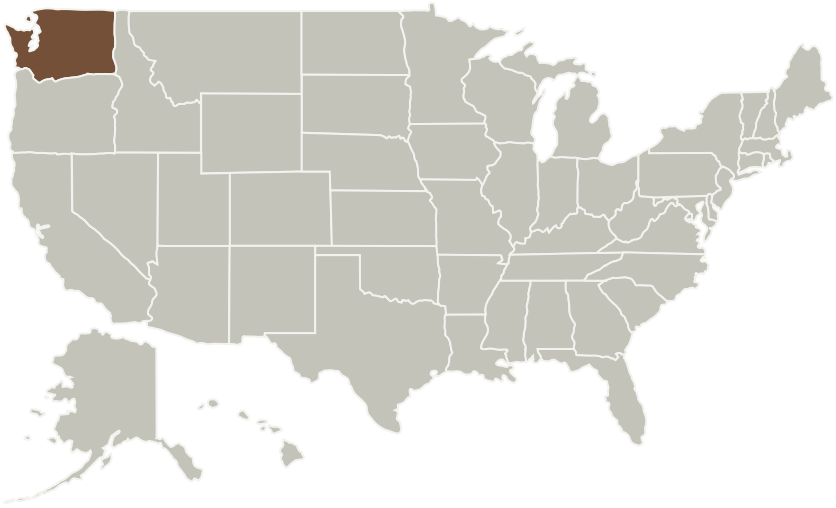
Hydrogen-Helium Mixtures: Fundamental Measurements, Neutral Droplet Buoyancy, Evaporation, and Boiling

Table of Contents

Hydrogen-Helium Mixtures: Fundamental Measurements, Neutral Droplet Buoyancy, Evaporation, and Boiling

Completed Technology Project (2014 - 2018)

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Washington State University	Lead Organization	Academia	Pullman, Washington

Primary U.S. Work Locations
Washington

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Washington State University

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Jacob Leachman

Co-Investigator:

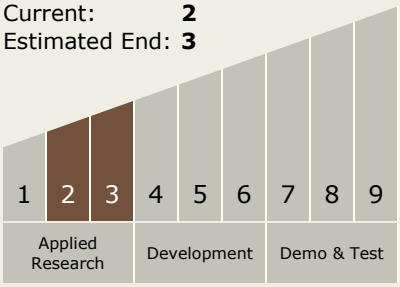
Ian G Richardson

Hydrogen-Helium Mixtures: Fundamental Measurements, Neutral Droplet Buoyancy, Evaporation, and Boiling

Completed Technology Project (2014 - 2018)

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX14 Thermal Management Systems
  - TX14.1 Cryogenic Systems
    - TX14.1.5 Cryogenic Analysis, Safety & Properties

Target Destinations

Mars, Foundational Knowledge, Others Inside the Solar System